DOCUMENT RESUME

ED 354 707 EC 301 892

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TITLE Curriculum Assessment Guide. Developing Science Curriculum for High Ability Learners K-8. Draft.
INSTITUTION College of William and Mary, Williamsburg, Va. School of Education.
SPONS AGENCY Department of Education, Washington, DC.
PUB DATE 92
NOTE 41p.
AVAILABLE FROM College of William and Mary, Center for Gifted Education, P.O. Box 8795, Williamsburg, VA 23187-8795 ($5).
PUB TYPE Guides - Non-Classroom Use (055) -- Tests/Evaluation Instruments (160)

EDRS PRICE MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS *Academically Gifted; *Curriculum Evaluation; Educational Change; Elementary Education; *Elementary School Science; Elementary School Students; *Evaluation Methods; Instructional Improvement; *Rating Scales; *Science Curriculum; Science Programs; Scientific Concepts

ABSTRACT

This guide is intended to assist in the evaluation of elementary science curriculum materials for use with high ability learners, in the light of calls for a "new science" which stresses depth of conceptual understanding. It presents a curriculum review process and two evaluation instruments. The process is intended to balance sound practices of traditional curriculum in science, the new instructional emphases, and differentiation issues for high ability learners. Phase I of the process looks for standard elements which should be present in any exemplary curriculum for any population. Phase II then focuses on recent recommendations of major science reform reports. Phase III criteria focus on differentiation for gifted learners, girls, and minorities. A chart compares 17 commonly used curricula based on 7 characteristics (reading based, inquiry based, media delivered, student research, interdisciplinary science tools, and activity based). A "Consumer's Guide Overall Rating Form" allows for comparative judgments of curriculum materials based on standard criteria. The evaluation form for all three phases is provided in both expanded (with explanations of each item) and brief forms. A sample narrative review of the "Great Explorations in Math and Science" program is provided. (Contains 36 references.) (DB)

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Developing Science Curriculum for High Ability Learners K-8 Series

Titles in this series include:

- A Conceptual Overview of Science Education for High Ability Learners
- Curriculum Assessment Guide
- Consumer's Guide to Science Curriculum
- Guide to Science Concepts
- Scope and Sequence of K-8 Science Curriculum for High Ability Learners
- Creating a New Science Curriculum
- Exemplary Teaching Units at K-2, 3-5, and 6-8 Grade Levels
- Notes from a Scientist: Suggested Resources and Activities for Gifted Children

funded by
The United States Department of Education

College of William and Mary
School of Education
Center for Gifted Education
Williamsburg, Virginia

1992

CURRICULUM ASSESSMENT GUIDE

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1992

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Appendix A: Sample Completed Curriculum Evaluation Narrative and Rating Forms

Introduction and Rationale: Science Curriculum Review

The task of evaluating science curricula for appropriateness with high ability students becomes critical in the context of national reform in science education. Several national organizations such as the American Association for the Advancement of Science and the National Science Teachers' Association have called for all science education to make fundamental changes both in content and in presentation of material. Depth of conceptual understanding takes precedence over breadth of factual coverage in the recommendations, in recognition of the rapidly expanding information base in science. All students should also be exposed to the nature of science, especially the practice of the scientific method and the attitudes of reasoned skepticism and tolerance of ambiguity associated with scientific thought. Changing the factual and didactic orientation of the current curricula to meet these new goals will require changing the very structures and foundations of the curriculum itself; a change in paradigm.

Two challenges are presented to reviewers of curricula who accept the validity and necessity of the "new science" regime. The first is to find a way to rate current science curricula which is fair to the intent of the publishers and authors while attending to the assumption that in order to be effective, science instruction will follow a significantly new form. Basal texts which may be evaluated as perfectly sound under the old paradigm may in fact look less promising when rated using "new science" standards. Nevertheless, such a review provides part of the demonstration of where and how changes need to be made to meet the demands of the 21st century.

The second challenge is to find a new and unique set of standards for determining differentiation for high ability students. The AAAS report 2061: Science for All Americans outlines scientific content, processes and attitudes which should be cultivated in all American students. This list, new to the goals of most general education programs, looks very much like the list of goals which teachers of the gifted have held for their students for some time. If all students should learn science concepts, learn to act and think like scientists, learn to independently hypothesize and experiment and analyze and infer, then what will the new set of goals for gifted students be?

A good core curriculum is an absolutely essential foundation to exemplary science instruction. Because of the interest in engaging students in science for the long term, it has become increasingly important to select or create science curriculum which simultaneously achieves several goals:

- The delivery of content which is substantive, up-to-date, and essential to an understanding of one or more science fields;

- The demonstration of science practices and "habits of mind" to give students practice in the behavior and thinking of scientists;

- The delivery of content and processes in a context which excites and entices students without diminishing the value of the content or reducing the practice of science to games or "magic."

- The opportunity for students to make connections between science areas and between science and other areas of study.

While such a core curriculum emphasis is essential for all learners, differentiating for the high ability learner requires responding to the scientific interests and behaviors displayed by these learners. These behaviors include: early curiosity and understanding about the world of science; ability to master the tools of science by demonstrating the activities, beliefs, and characteristics of scientists; ability to reason analytically,

deductively, and inductively with more complex material; and the energy and persistence to solve real problems of science. Thus, high ability learners need advanced science content earlier and at a more complex and abstract level than do other learners, even under the new science model.

Our goal for assessing science materials is to create a fair balance among sound practices of traditional curriculum in science, the new instructional emphases, and differentiation issues for high ability learners. Three phases of review were created to provide this balance. In Phase I, general curriculum features are critiqued working from the assumption that there are standard elements which must be present in any exemplary curriculum in any paradigm and for any population. The "new science" paradigm is reflected in Phase II of the review which was crafted around the recommendations of major science reform reports and input from scientists. Together, these criteria create a powerful guide for the review of any science curricula, including basal texts and ancillary materials. The Phase III criteria for differentiation for special populations reflects an existing synthesis of approaches to modifying curriculum for gifted learners, girls, and minorities.

To facilitate the process of curriculum review, and especially the interpretation of the ratings derived from the reviews, two parallel products were created to accompany the Phase I, II, and III criterial rating forms. The first is a "consumer's guide" form which encapsulates the fundamental findings from the criterial rating sheets. Overall judgments reached from the rating can be compared across curricula using this standard form for quick reference. The second product is a narrative review which provides substance and context to the codified information provided through the rating forms and consumer's guide. Although the substance of the narrative, like the consumer's guide, is derived directly from the rating sheets, its format allows for a more comprehensive discussion of a curriculum's strengths and weaknesses.

Because curriculum materials are considered so crucial to the enterprise of science teaching, we believe that this curriculum assessment guide should be reviewed by all school districts in the country who are interested in science learning for high ability students. The users of this guide may be 1) curriculum developers, 2) district-based curriculum or textbook review committees, or 3) individual teachers interested in materials review for classroom use. We hope the process conveys a reasonable approach to decision-making about educational materials in science and that practitioners will find it helpful.

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The Curriculum Review Process

Introduction

The curriculum review process evolved through several phases. It included a review of the literature calling for educational reforms in the 21st century, a search for materials, developing criteria, reading curricula, contacting publishers and developers for research evidence of effectiveness, numerous discussions among reviewers to reach consensus, and the writing of reviews. As a dynamic process, it changed and grew as each phase occurred and informed the other phases. Throughout the process, the definition and conception of an exemplary science curriculum for gifted learners expanded to accommodate the instructional needs of students, the information and technical needs of teachers, and the rigorous demands of true scientific literacy.

The Search for Materials

The curriculum review process started with the search for worthy curricula to review. Given earlier grants in science education, the Center for Gifted Education had ready access to several excellent materials. The science consultant team also was asked for specific curriculum, and they provided an overview of science curriculum that spanned projects from the 1960's to the curriculum projects that are currently under development.

The National Science Resources Center (NSRC), a curriculum resource center and information database established by the Smithsonian Institute and the National Academy of Sciences, served as a major source of information. Their publications, Science for Children: Resources for Teachers, and the NSRC Newsletter provided access to numerous curricula.

Letters soliciting curriculum for review were sent to all science curriculum publishers listed in NSRC's Science for Children: Resources for Teachers. Although not all publishers submitted their curricula, the resulting correspondence alerted project staff to new materials.

An ongoing, extensive literature search yielded additional sources and curricula. The ERIC CD-ROM database and professional science journals from the past two years were the major sources of information. Other major sources used to locate curricula are included in the reference section of this guide.

Selection of Materials to Review

The search for materials resulted in a bibliography that listed 62 curricula in the categories of basal text series, inquiry-based/hands-on materials, research-oriented materials, interdisciplinary and applied science materials, and curriculum resources. From this bibliography, a representative sample of curricula was selected for review. The rationale for selection included: breadth of use, reputation and/or evidence of appropriateness for high ability students, reputation as 'seminal' texts, and reputation as innovative or prototypical. After the initial review of 17 curricula, a new categorical system was developed that emphasized the primary focus of the reviewed materials. These categories were found to be: reading-based, inquiry-based, media-delivered, student research, interdisciplinary, science tools, and activity-based. This categorical system then guided the review of remaining curricula in the project.

The initial 17 curricula selected for review are listed by the newly designated categories in the following chart.

Sample Curricula Selected for Review

Title	Reading Based	Inquiry Based	Media Delivered	Student Research	Inter-Disciplinary	Science Tools	Activity Based
Activities to Integrate Mathematics & Science (AIMS)							X
Chemical Education for Public Understanding (CEPUP)		X			•		•
Challenge of the Unknown		•	X		•		•
Discover Science +	X						
Full Option Science System (FOSS)		X					•
Great Explorations in Math & Science (GEMS)		X		•			•
Insights		X					•
LEGO/Logo		•				X	•
National Geographic Kids Network		•		•	•	X	•
Science & Technology +	X						
Science & Technology for Children		X			•		•
Science for Life & Living	•	X			•		•
Search for Solutions	•		X		•		
Students & Research				X			
Voyage of the Mimi			•		X		
Windows on Science +			X				

Key: X = primary focus of curricula * = element of curriculum but not primary focus + = intended for use as a basal

Under this broadened categorical system, science textbooks may most often be found under "reading-based." The science textbooks reviewed represent those most commonly used in the United States. To determine common usage, several state-level science supervisors were contacted. It was discovered that many states do not compile information as to the texts used in that state. For instance, California has a state-approved adoption list, but individual districts are responsible for their own ordering and make no report of textbook use to state agencies. In New York, a nonadoption state, districts make local decisions, and might generate their own materials rather than purchase textbooks.

The following chart summarizes the survey of science textbooks reviewed for this project.

Survey of Science Textbooks

(Numbers listed in the state columns indicate ranking of text use in that state, an X indicates that the curriculum is adopted, but usage statistics are not available.)

Publisher	Series Title	Grade Level	VA[1]	IL[2]	MS[3]	TX[4]
Scott Foresman	Discover Science	1-6	1	1	X	X
Merrill	Merrill Science	1-6	2	X	X	X
Addison-Wesley	A-W Science	1-6	3	X		
Silver Burdett & Ginn	SB & G Science	1-6	4	X	X	1 (80%)
Holt	Holt Science	1-6	5			X
Prentice-Hall	Life Science	6-9		X		
Prentice-Hall	Earth Science	7		X		
Prentice-Hall	Physical Science	8			X	
Merrill	Focus on Earth Science	7			X	
Merrill	Focus on Physical Science	8			X	

[1] = Virginia, [2] = Illinois, [3] = Mississippi, [4] = Texas

Development of Criteria

Criteria for evaluating curriculum were developed by the project that provided a multifaceted lens for looking at various curricular components. Organized into three categories: (1) general curricular issues, (2) science content and process issues, and (3) features that tailor the curriculum for special populations, the criteria enabled reviewers to focus on areas of concern and to identify specific strengths and weaknesses. Therefore, it was possible to find a curriculum strong in science content but weak in science process. Likewise, the curricular design of a set of materials might be deficient, but the activities within the materials could be recommended as useful resources. The comprehensive scope of the criteria forced reviewers to consider curriculum effectiveness from the instructional needs of teachers, the content and process demands of science, and characteristics of various groups of learners.

General Curriculum Features

The first group of criteria, general curriculum features, considered the construction of the curriculum. These criteria addressed design features, classroom design features, and technology. Here, the perspective of the teacher and instructional demands of the classroom were of primary concern. Each curriculum was evaluated for its overarching goals and how those goals were attained through the presentation of content. Then activities and materials were examined to determine how well they reflected the goals and content in addition to offering variety and being developmentally appropriate. Each curriculum was also evaluated for the presence and authenticity of multiple assessment procedures that measure outcomes as stated by program goals.

When the curriculum was based on technology such as interactive video or computers, a separate section of criteria looked at how successfully the technology was implemented. Here, the twofold purpose was to scrutinize what the technology offered that printed materials could not deliver and whether the use of technology fulfilled the demands of effective instruction.

Exemplary Science Features

This section of the criteria represented the specific elements of science curricula which are recommended in several new reports from science and mathematics foundations including Science for All Americans: Project 2061 (AAAS, 1987) and Science Learning Matters (NAEP, 1988). Those reports recommended that curricula integrate scientific thinking with scientific behaviors and attitudes, make inter- and intra-disciplinary connections, encourage active and real (not "cookbook") exploration, focus on learning key concepts instead of "covering the material," and demonstrate the connections between scientific discovery and moral and ethical decision-making.

The criteria ensured that curricula provide students with the opportunity to study areas of science where research is relatively new and as of yet still theoretically unformulated as in the current state of research on possible health hazards associated with nuclear power. From this kind of study students learn the essential ambiguity of science, the role of personal values in interpreting data and that the study of science does not result in absolute answers.

Tailoring for Special Populations

The criteria for differentiation for high ability learners were expanded from the "general curriculum features" section. Here, higher order thinking skills and scientific thinking skills, learning through discovery, and creation of real products were of primary concern. In addition to these skill-based goals, the curricula should also challenge talented students to develop a qualitatively different frame of reference. For example, students should come to realize that knowledge is constructed instead of prescribed and that specific criteria are used in each discipline to judge the relative worthiness of conflicting information.

In order to engage women and minorities in science, curriculum must be sensitive to their unique perspectives. For women, it means opportunities to "connect" information by representing it in a context which is personally relevant and to make associations among areas of study. Both the study of and direct access to appropriate role models is desirable. For minorities, this means conscious adaptation of content to represent the perspectives of the minority student and instructional adaptations to fit their learning styles. For disabled students this means providing greater individualization and flexibility in how, where, and under what circumstances science may be learned. All special population groups also would benefit from the realization that science, far from being cold, impersonal and isolated, is intimately linked with the world of people.

The Review Process

Three reviewers with different expertise and perspectives evaluated each curriculum by using the criteria developed by the project. First, a materials specialist conducted a thorough review of the entire curriculum by applying all three sections of criteria (Phase I, II, and III). The general curriculum features were rated on a scale of 1-3. The sections that address exemplary science features and tailoring for special populations were rated on a scale of 1-5. In addition, specific examples of how the curriculum met or failed to meet certain criteria were noted during this part of the review.

Secondly, an expert in gifted education and curriculum development rated each curriculum by completing the "general curriculum features" section (Phase I) and the "differentiation for gifted learners" section (Phase III) of the criterial checklists. Likewise, a scientist rated the curriculum by completing the "exemplary science features" (Phase II) and "curriculum responsiveness to girls, minority concerns, and disabled" section (Phase III) of the criterial checklists. For curricula spanning the elementary grades, these two specialists critiqued grades two and six. In the cases of secondary curricula and resource materials, they critiqued the entire program. Both specialists made comments about particularly salient strengths and weaknesses of the curriculum as they conducted their reviews.

Using the comments and ratings from the gifted education expert and the scientist, the materials specialist then wrote a narrative review. Comments about the narrative were solicited from project staff, and the narrative was then revised. In this manner, a holistic review emerged based on criterial checklists as well as the responses of experts representing at least three different perspectives.

Finally, a rating scale was formulated to highlight strengths and weaknesses in the three phases of each curriculum. The scores each reviewer marked on the criterial checklists were averaged to obtain that reviewer's rating in the areas of curriculum design, classroom design, technology, science content, science process, and high ability learners. When a curriculum was particularly appropriate for the intellectually gifted, science-prone, girls, minorities, or disabled students, that strength was also noted on the rating scale. Then the scores of the three reviewers were averaged and the resulting scores were used to assess the curriculum as "recommended," "adequate," or "not recommended" in each of the rated areas (see Appendix A for sample completed review forms).

The Narrative Review

The narrative review, the final piece of the review process, includes three sections: an overview, an analysis, and a conclusion.

The Overview

The overview orients the reader to the scope and presentation of the curriculum. This section contains a description of the materials, a listing of the major program goals, and a summary of the research evidence of the effectiveness of the program.

The major goals and objectives of a curriculum reflect the substance of the program and provide a glimpse of the program developers' vision. The goals listed in this part of the review are taken directly from the curriculum materials. Some curricula contain no statement of major goals or objectives, and this fact is reported in the review. The omission of major goals, of course, precludes an overall research assessment of the effectiveness of the program.

The report of research evidence of effectiveness of a program informs readers if the program was field tested, followed up with summative research, or simply the result of commercial market research. In seeking research evidence for the reviews, ERIC data bases were searched for pertinent research reports. In addition, written requests for research evidence were sent to the publishers or producers of the curricula

under review. For the purpose of these reviews, primarily research effectiveness of student learning, not teacher or student perception, is considered valuable.

The Analysis

The analysis of the curriculum which flows directly from the Phase I-III rating criteria contains three sections: (1) General Curriculum Features, (2) Exemplary Science Features, and (3) Tailoring for Special Populations. The first section, General Curriculum Features, considers curriculum design, classroom design, and technology aspects. Then, Exemplary Science Features, evaluates how well the curriculum meets the criteria for exemplary science content and science process. Finally, the analysis discusses how the curriculum accommodates or could be adapted to meet the unique needs of high ability learners, girls, minority students, and disabled students. The analysis offers educators consistent, comprehensive standards by which to compare one curriculum to another.

The Conclusion

The conclusion of the review summarizes the major strengths and weaknesses of the curriculum. It synthesizes information gleaned from the statement of major goals, the research evidence of effectiveness, and the analysis of how well the curriculum meets established criteria. (See Appendix B for a sample narrative review.)

Summary

The review process offered an opportunity to view and review curriculum from the perspectives of various professionals and instructional demands. The criterial checklists served as the cornerstone of the review process, and provided the lens for the objective look at each curriculum. The rating scale then summarized the results of the checklists and gave consumers an opportunity to compare one curriculum with another. The narrative, the final piece of the review process, summarized the objective examination of each curriculum, including the more subjective reactions of the three reviewers, and offered suggestions and caveats for using the curricula in classrooms.

General Curriculum Features Evaluation Form
(Phase I Review)

Curriculum Design

1. Rationale and Purpose

This feature addresses the reasons for developing a particular unit of study for use with a given group of learners at a particular stage of development. It provides the reader with a sense of the importance of the topic under study and why it is being taught.

--substantive and worthy? 3 2 1

Content is important and valuable; publishers/authors provide reasons why content was selected or the value is self-evident.

--clear and understandable? 3 2 1

Teachers can easily tell why the selected content is important. Rationale and purpose are written in meaningful and clear language rather than in educational and/or scientific jargon.

--logical order and integrated structure to scope and sequence? 3 2 1

The suggested order for presentation of topics and concepts makes sense both within a grade and from grade to grade.

--identified outcomes consonant with purpose? 3 2 1

The content and processes identified as desired goals of learning are consistent with the stated reasons to learn.

2 Curriculum Content

This feature provides the scope of the unit in respect to content treatment and allows the reader to see the interrelationships of ideas that will guide the unit development process.

--significant scientific concepts? 3 2 1

The science content is central to fundamental understanding about a science content area and/or the scientific process.

--significant information to explore concepts in depth? 3 2 1

Enough factual information should be provided to cover selected concepts in depth, as opposed to a cursory sampling of information across many concepts.

--topics support concepts? 3 2 1

Individual areas of study in the curriculum illuminate/provide examples for larger, more abstract science concepts.

--engaging style of present information? 3 2 1

The material is attractive (well-illustrated, up-to-date, etc.), catches the attention of the learner, and engages the learner.

--topics and activities have personal meaning and social relevance for students? 3 2 1

Information is presented from a child's point of reference.

--allowance for curricular differentiation for gifted learners? 3 2 1

The possibility to adjust content level or pace and acceleration of the curriculum exists. Suggestions for such adaptations are provided.

3. Curriculum Responsiveness to Developmental Needs

This feature of the curriculum assures that there is an optimal match between the developmental readiness of the learner and the curricular expectations.

--sequential exposure to scientific concepts from the concrete to the abstract? 3 2 1

Depending on the age and/or grade level, the science ideas shift from being tangible with hands-on tasks and/or basic explanations to a more abstract and generalizable form.

--manipulative science materials used to support the curriculum? 3 2 1

There are activities and resources available or suggested so that students can "do" science.

--high active to passive activity ratio? 3 2 1

The curriculum requires that students be active through numerous hands-on activities.

--sequential use of visual materials from the picto-centric to the text-centered? 3 2 1

Content is presented primarily through engaging and interesting pictures in early primary grades and moves to proportionately higher percentage of written text in higher grades.

--materials challenge students' current explanations and allow time for them to reconstruct their understanding of scientific phenomena? 3 2 1

Since students often hold primitive or incorrect views of scientific phenomena, the materials force them to recognize their own incorrect ideas and re-evaluate their thinking.

Classroom Design

4. Instructional Objectives

This feature provides the focus and direction for learning in the unit. It specifies anticipated outcomes for students as a result of being taught a unit of study.

--clear and understandable? 3 2 1

A curriculum reader would know immediately what the students will be able to know and/or do as a result of a unit of study.

--measurable? 3 2 1

Techniques or suggestions are provided for teachers so they can tell whether or not they have achieved the learning outcomes.

--related to overall rationale and purpose? 3 2 1

The goals of an individual unit are consistent with the goals of the curriculum as a whole.

5. Activities

This feature specifies what teachers will do to facilitate learning and what students will do to learn.

--appropriate balance of teacher direction/student direction? 3 2 1

Room is provided in the curriculum to both meet teacher goals and allow for students to participate and contribute to the class.

--developmentally appropriate activities? 3 2 1

The activities take into account the level of cognitive, emotional and physical development that is likely to be found in learners who will be doing these activities. Activities are challenging, yet achievable.

--activities used to introduce topic (get students to explore topic to be studied)? 3 2 1

There activities used to get students interested in the topics are fun/interesting, rather than reading or lecture.

--activities clarify, reinforce and extend content? 3 2 1

Activities serve a purpose related to learning content beyond repeating what students already know. They directly support the content-base of the unit.

--science integrated with other subjects, specifically language arts and mathematics? 3 2 1

Interdisciplinary connections are presented.

6. Instructional Strategies

This feature provides direction to readers around the major approaches to teaching that will be undertaken. It specifies heuristic models, questioning techniques, and conferencing approaches used by the teacher.

--are strategies varied? 3 2 1

Several different forms of instruction are suggested (e.g. inquiry activities, lecture, laboratory work, independent work, etc.)

--opportunities for problem finding and solving? 3 2 1

Students are encouraged to identify and solve problems that are not explicitly set out for them in advance.

--opportunities for open inquiry? 3 2 1

Problems, projects, etc. are open-ended with respect to the solution or approach to the solution. Students are encouraged to formulate questions and explore possible answers to those questions.

--varied grouping approach, e.g., including opportunities for small group work? 3 2 1

The curriculum suggests both large and small group activities and different ways these groups can be formed and used.

--cooperative work focuses on real problems with problem resolution rather than problem solution as goal? 3 2 1

The process of solving problems is treated as more important than the "right answer."

--opportunities to practice decision making strategies? 3 2 1

Students are encouraged to make decisions rather than have the teachers tell them all procedures and outcomes.

--use of various types of questions (e.g., convergent, divergent, evaluative)? 3 2 1

There are a variety of questions suggested which stimulate different levels of thought, from knowledge through evaluation.

7. Assessment Procedures

This feature specifies how students will be assessed in respect to their learning in the unit. It provides documentation for learning outcomes.

--presence of pre-post assessment measures? 3 2 1

There are opportunities at both the beginning and the end of the unit to measure knowledge so that relative gain can be measured.

--use of observational evaluation? 3 2 1

Opportunities for assessment by observation are included.

--use of authentic assessment? 3 2 1

There are opportunities to evaluate students doing "real," actual science rather than a written test.

--objective attainment assessment measures? 3 2 1

There are evaluation strategies which measure directly whether or not the student has met an objective.

--assessment based on ability to get and to use information? 3 2 1

Assessment procedures require students to access and use information, rather than simply recognize facts.

--assessment based on outcomes of significance? 3 2 1

The objectives that are assessed are ones that are valuable and important to science concepts, processes, or attitudes.

--opportunity for overall evaluation? 3 2 1

Opportunity is provided for a holistic, integrated final evaluation. There is some way of assessing whether objectives for whole unit or curriculum have been achieved.

8 Materials/Resources

This feature provides bibliographic references for use in implementing the unit. It includes both resources for teachers and materials for student use.

--instructional materials begin with students' current knowledge? 3 2 1

The materials provide for diagnostic assessment of knowledge and skills and/or introductory activities that encourage teacher assessment of knowledge levels.

--supportive bibliography for teachers? 3 2 1

Resources are suggested for teachers to enhance their knowledge of the subject.

--frequent student misconceptions are identified for teachers? 3 2 1

Teachers are alerted to what errors or common pitfalls students commonly make.

--bibliography for student extension reading? 3 2 1

Bibliographies are provided for the learners.

--supportive handout materials (informational, worksheets, etc.)? 3 2 1

Materials are included that are ready for duplication and that support the basic curriculum unit.

9. Extension Ideas

This feature specifies follow-up learning opportunities for students that go beyond the prepared unit of study but are logical next activities, based on unit work. Suggestions for both group and independent work should be encouraged.

--worthwhile, related activities for students to pursue independently? 3 2 1

Meaningful suggestions are included for ways a student can extend the school learning experience to the home environment. Ideas, activities, and resources are suggested so the individual student can do extended work on a given topic, concept or theme.

Technology Features *

This set of features specifies the extent to which the technology aspect of the curriculum is appropriate and effective in enhancing science learning experiences.

General 3 2 1

--actively engages students in higher order thinking skills and activities?

--enhances and complements instruction?

--provides effective interaction?

--allows exploration otherwise prohibited by time, danger, or money?

--provides simulations of models or experiments that cannot be experienced with real materials?

--contains several levels of difficulty?

--provides useful, corrective feedback?

--easy to use?

Technical

--uncluttered screen design?

--lucid, economical text?

--dynamic visuals for abstract concepts?

--useful help screens?

--effective self-pacing devices?

--comprehensive teacher manual that includes instructions for use and modification, inventory, and specifications?

* This feature was not rated if the curriculum materials did not include it.

Exemplary Science Features Evaluation Form
(Phase II Review)

Science Content

1. --content base in key areas of science that provide the fundamentals of basic science? 5 4 3 2 1

The curriculum covers areas of science that are basic for a good understanding of modern science, rather than covering trivial or peripheral topics.

2. --content base in key areas of technology? 5 4 3 2 1

The curriculum covers areas that are basic for an understanding of modern technology, rather than showcasing flashy or otherwise inaccessible technology.

3. --inclusion of current science/technology content? 5 4 3 2 1

The scientific content is up-to-date; discoveries made in the last decade which are germane to the material are discussed; content reflects an understanding of current science by the curriculum writers.

4. --inclusion of historical and current science/technology issues? 5 4 3 2 1

Historic and current science/technology issues (such as AIDS or the catastrophe theory of the extinction of the dinosaurs) are included to give students a sense of the controversy which can accompany the introduction of new scientific ideas.

5. --topics linked to broad scientific concepts (intradisciplinary connections)? 5 4 3 2 1

The topics covered are explained in terms of their relevance to broad scientific concepts (such as evolution) rather than presented as unconnected facts or ideas.

6. --topics linked to ideas outside of science (interdisciplinary connections)? 5 4 3 2 1

Scientific topics of immediate relevance to areas outside science are discussed and explicitly linked to those areas.

7. --balance of qualitative and quantitative information? 5 4 3 2 1

Scientific information is presented in both narrative and numerical terms as appropriate. The curriculum does not shy away from necessary quantitative information.

8. --balance of theoretical and practical science? 5 4 3 2 1

Both the theories of science (gravity and the Copernican theory) and their applications (eclipse, prediction, seasons, artificial satellites) are presented.

9. --presence of moral and ethical dimensions of science and technology? 5 4 3 2 1

Science and technology should be presented as initiating new, complex and ambiguous moral and ethical dilemmas which require discussion and resolution by parties with conflicting viewpoints.

10. --global perspectives on relationship of science and technology to society and to developing nations? 5 4 3 2 1

Science and technology should be presented as a part of the real world; their effects on and implications for society should be discussed.

11. --science is accurate and presented understandably? 5 4 3 2 1

The science presented is factually correct and presented such that the important facts and ideas of the area under discussion are readily apparent.

12. --important science concepts are covered in depth? 5 4 3 2 1

The curriculum presents sufficient information on the important ideas of science for the student to be able to understand their power and relevance. Trivial and inessential material does not compete with important material for the student's attention.

13. --provision for the use of technology (e.g., computers, CD-ROM) as it can be applied to science? 5 4 3 2 1

The curriculum provides for the use of appropriate technology by students for their own scientific purposes (not merely for science TEACHING purposes).

14. --opportunities for open-ended scientific investigation (not simply verification exercises)? 5 4 3 2 1

Opportunities for scientific investigation in which the student may not know the answer or have a protocol provided beforehand are present; students can design and perform their own experiments.

15. --use of community resources? 5 4 3 2 1

Suggestions are made when appropriate for use of community resources. Examples would include take a field trip to see . . . , bring in a nurse to talk about . . ., and so on.

16. --laboratory and field-work integral to and integrated with the curriculum? 5 4 3 2 1

Any use of the curriculum demands that the students actively participate in labs and fieldwork. Labs are not optional activities, but rather contribute directly to the development of the child's scientific understanding.

Science Process

17. --opportunities for students to have personal interaction with people practicing science? 5 4 3 2 1

Suggestions are made for the integration of scientists into the students' science experience. For example, the strong suggestions could be made that a doctor be brought in to discuss nutrition, rather than the teacher; that a geologist be brought along on a field trip; and so on.

18. --concern for career awareness? 5 4 3 2 1

Students are exposed to the various jobs associated with a given field of science.

19. --opportunities for students to work together to investigate a scientific/technological problem? 5 4 3 2 1

Students should be given the opportunity to investigate a scientific problem by working cooperatively in small groups.

20. --opportunities for students to work with a mentor to investigate a scientific/technological problem? 5 4 3 2 1

Students should be given the opportunity to investigate a science problem under the guidance of an adult mentor.

21. --use of various questioning strategies integrated throughout the curriculum? 5 4 3 2 1

Students should be challenged through the use of higher level (evaluation, synthesis, and analysis) questions and be asked to think thoroughly with the use of probing questions.

22. --active student involvement required by curriculum? 5 4 3 2 1

Students cannot "get by" by reading the book and listening in class. They must also participate in laboratory activities, contribute to discussions, write reports, investigate scientific problems alone or in groups . . .

23. --scientific process demonstrated as approximation versus absolute rigidity? 5 4 3 2 1

Students must be given an understanding of the way scientific ideas are developed (educational hunches, inference, and speculation supported by experiments with limitations), both by curriculum containing descriptions of scientific controversies and their resolution, and by actively doing science in the lab and field.

24. --students are taught to build and test hypotheses? 5 4 3 2 1

Students should be required to design and perform experiments, building hypotheses using their understanding of science and the world and then testing them experimentally.

25. --allowance for questioning of assumptions and diverse opinions? 5 4 3 2 1

Opportunities should be present for students to experience the development of a scientific idea; different points of view, questioning of the viewpoints and assumptions of others, and the bringing in of additional information to resolve disputed points should be included.

26. --examples of unsuccessful science so that science-as-a process is demonstrated? 5 4 3 2 1

Students should both be allowed to obtain negative or ambiguous experimental results and to read about scientists who had similar experiences in the lab. This is most likely to happen in open-ended experimental situations.

Tailoring for Special Populations Evaluation Form
(Phase III Review)

Differentiation for High Ability Learners

1. --provisions for acceleration and compression of content? 5 4 3 2 1

   Curriculum skills and concepts are organized on a sequence from "easy to difficult" concepts that would allow for easy teacher adaptation to students' individual instructional level.

2. --use of higher order thinking skills? 5 4 3 2 1

   The curriculum includes activities and questions that require learners to think at the levels of analysis, synthesis, and evaluation.

3. --integration of content by key ideas, issues, and themes? 5 4 3 2 1

   The curriculum is organized according to broad-based concepts in science, such as change, patterns, and systems.

4. --connection of scientific ideas to other disciplines? 5 4 3 2 1

   The curriculum illustrates how scientific ideas have salience in other content areas such as music, art, literature, social science, and mathematics.

5. --opportunities for both inductive and deductive reasoning? 5 4 3 2 1

   The curriculum guides students 1) to create specific illustrations, examples, and details that support a given generalization, and 2) to engage in thinking to form generalizations from specific case examples or data that are provided.

6. --use of multiple teaching resources? 5 4 3 2 1

   The curriculum encourages the use of multiple media, multiple readings, multiple activities from other materials to teach skills and concepts.

7. --use of diagnostic-prescriptive teaching? 5 4 3 2 1

   The curriculum provides an assessment approach that allows for pre-testing and post-testing as well as on-going assessment of learners' mastery of skills and concepts.

8. --attention to instructional pacing? 5 4 3 2 1

   The teachers' guide notes that some learners can master the basic science content at a rate faster than other learners.

9. --advanced reading level? 5 4 3 2 1

   The curriculum readability index is pitched at least one or two grade levels beyond the given designated level.

10. --opportunities for students to develop advanced products? 5 4 3 2 1

The curriculum provides suggestions for teachers to support student projects that involve original investigation.

11. --opportunities for independent learning based on student capacity and interest? 5 4 3 2 1

The curriculum provides extension activities to be undertaken by students alone in various settings.

12. --use of inquiry-based instructional techniques? 5 4 3 2 1

The curriculum is based on a model of questioning that promotes the role of the student as investigator.

Curriculum Responsiveness to Intellectually Gifted

The materials provide consideration for the top five percent of the student population through the extensiveness of advanced content and the complexity of the content provided.

5 4 3 2 1

Curriculum Responsiveness to Science Prone Students

The materials provide consideration for students who have an avid interest in and aptitude for doing science through an emphasis on open-ended opportunities, extended lessons and in-depth learning experiences.

5 4 3 2 1

Curriculum Responsiveness to Girls

The materials provide consideration for gender bias and stereotyping, use of positive role models and inclusion of teaching strategies found conducive to girls' enhanced learning.

5 4 3 2 1

Curriculum Responsiveness to Minority Concerns

The materials provide consideration for ethnic bias and stereotyping, use of positive role models, inclusion of non-western cultural contributions to science, and strategies found conducive to minority students enhanced learning.

5 4 3 2 1

Curriculum Responsiveness to Disabled Students

The materials provide consideration for broad individual differences through individualized techniques and practices, tools for compensation, and attention to varied formats for guided practice.

5 4 3 2 1

The Consumer's Guide Overall Rating Form found below represents a synthesis of the key features evaluated for each set of curriculum materials reviewed. The numerical average of the reviewer forms for each feature were transferred one to this single sheet so that rating recommendations might be made according to individual features of the curriculum. For example, some curricula were very strong in science process and thus recommended for that feature. The same curricula may be found inadequate in curriculum design and thus not recommended based on that feature. The purpose and function of this rating form then is to provide a shorthand coding for the results of the multi-layered review process.

Consumer's Guide Overall Rating Form

Title of Materials	Curriculum Design	Classroom Design	Technology	Exemplary Science Content	Exemplary Science Process	High Ability Learners	Notes

Rating Scale:	Recommended = +	Adequate = 0	Not Recommended = -
(1-3 scale)	2.50 - 3.00	1.50 - 2.49	below 1.50
(1-5 scale)	3.75 - 5.00	2.25 - 3.74	below 2.25

Note: Appropriate for (A) Intellectually Gifted; (B) Science Prone; (C) Girls; (D) Minorities; (E) Disabled Students

General Curriculum Features Evaluation Form
(Phase I Review)

Name of Reviewer: _____

Title: _____

Title of Curriculum to be Reviewed: _____

Appropriate Grade Level(s): _____ Original Copyright Date: _____ Date(s) of Revision: _____

Directions: Carefully read through all curriculum materials and then rate the curriculum by each of the following criteria on a scale of 3 = To a great extent; 2 = Adequate; and 1 = Not at all:

		3	2	1
Curriculum Design				
1.	Rationale and Purpose	3	2	1
	--substantive and worthy?	3	2	1
	--clear and understandable?	3	2	1
	--logical order and integrated structure to scope and sequence?	3	2	1
	--identified outcomes consonant with purpose?	3	2	1
2.	Curriculum Content	3	2	1
	--significant scientific concepts?	3	2	1
	--significant information to explore concepts in depth?	3	2	1
	--topics support concepts?	3	2	1
	--engaging style of presenting information?	3	2	1
	--topics and activities have personal meaning and social relevance for students?	3	2	1
	--allowance for curricular differentiation for gifted learners?	3	2	1
3.	Curriculum Responsiveness to Developmental Needs	3	2	1
	--sequential exposure to scientific concepts from the concrete to the abstract?	3	2	1
	--manipulative science materials used to support the curriculum?	3	2	1
	--high active to passive activity ratio?	3	2	1
	--sequential use of visual materials from the picto-centric to the text-centered?	3	2	1
	--materials challenge students' current explanations and allow time for them to reconstruct their understanding of scientific phenomena?	3	2	1
Classroom Design		3	2	1
4.	Instructional Objectives	3	2	1
	--clear and understandable?	3	2	1
	--measurable?	3	2	1
	--related to overall rationale and purpose?	3	2	1
5.	Activities	3	2	1
	--appropriate balance of teacher direction/student direction?	3	2	1
	--developmentally appropriate activities?	3	2	1
	--activities used to introduce topic (get students to explore topic to be studied)?	3	2	1
	--activities clarify, reinforce and extend content?	3	2	1
	--science integrated with other subjects, specifically language arts and mathematics?	3	2	1
6.	Instructional Strategies	3	2	1
	--are strategies varied?	3	2	1
	--opportunities for problem finding and solving?	3	2	1

	--opportunities for open inquiry?	3	2	1
	--varied grouping approach, e.g., including opportunities for small group work?	3	2	1
	--cooperative work focuses on real problems with problem resolution rather than problem solution as goal?	3	2	1
	--opportunities to practice decision making strategies?	3	2	1
	--use of various types of questions (e.g., convergent, divergent, evaluative)?	3	2	1
7.	Assessment Procedures	3	2	1
	--presence of pre-post assessment measures?	3	2	1
	--use of observational evaluation?	3	2	1
	--use of authentic assessment?	3	2	1
	--objective attainment assessment measures?	3	2	1
	--assessment based on ability to get and to use information?	3	2	1
	--assessment based on outcomes of significance?	3	2	1
	--opportunity for overall evaluation?	3	2	1
8.	Materials/Resources	3	2	1
	--instructional materials begin with students' current knowledge?	3	2	1
	--supportive bibliography for teachers?	3	2	1
	--frequent student misconceptions are identified for teachers?	3	2	1
	--bibliography for student extension reading?	3	2	1
	--supportive handout materials (informational, worksheets, etc.)?	3	2	1
9.	Extension Ideas	3	2	1
	--worthwhile, related activities for students to pursue independently?	3	2	1
Technology Features		3	2	1
10.	General	3	2	1
	--actively engages students in higher order thinking skills and activities?	3	2	1
	--enhances and complements instruction?	3	2	1
	--provides effective interaction?	3	2	1
	--allows exploration otherwise prohibited by time, danger, or money?	3	2	1
	--provides simulations of models or experiments that cannot be experienced with real materials?	3	2	1
	--contains several levels of difficulty?	3	2	1
	--provides useful, corrective feedback?	3	2	1
	--easy to use?	3	2	1
11.	Technical	3	2	1
	--uncluttered screen design?	3	2	1
	--lucid, economical text?	3	2	1
	--dynamic visuals for abstract concepts?	3	2	1
	--useful help screens?	3	2	1
	--effective self-pacing devices?	3	2	1
	--comprehensive teacher manual that includes instructions for use and modification, inventory, and specifications?	3	2	1

Exemplary Science Features Evaluation Form
(Phase II Review)

Name of Reviewer: _____

Title: _____

Title of Curriculum to be Reviewed: _____

_____ Appropriate Grade Level(s): _____

Directions: Carefully re-read through all curriculum materials and then, rate the curriculum by each of the following criteria on a scale of 5 = To an Exemplary Extent; 4 = To a Good Extent; 3 = Adequate; 2 = To a Limited Extent; and 1 = Not at All.

Science Content		5	4	3	2	1
1.	--content base in key areas of science that provide the fundamentals of basic science?	5	4	3	2	1
2.	--content base in key areas of technology?	5	4	3	2	1
3.	--inclusion of current science/technology content?	5	4	3	2	1
4.	--inclusion of historical and current science/ technology issues?	5	4	3	2	1
5.	--topics linked to broad scientific concepts (intradisciplinary connections)?	5	4	3	2	1
6.	--topics linked to ideas outside of science (interdisciplinary connections)?	5	4	3	2	1
7.	--balance of qualitative and quantitative information?	5	4	3	2	1
8.	--balance of theoretical and practical science?	5	4	3	2	1
9.	--presence of moral and ethical dimensions of science and technology?	5	4	3	2	1
10.	--global perspectives on relationship of science and technology to society and to developing nations?	5	4	3	2	1
11.	--science is accurate and presented understandably?	5	4	3	2	1
12.	--important science concepts are covered in depth?	5	4	3	2	1

Science Process		5	4	3	2	1
13.	--provision for the use of technology (e.g., computers, CD-ROM) as it can be applied to science?	5	4	3	2	1
14.	--opportunities for open-ended scientific investigation (not simply verification exercises)?	5	4	3	2	1
15.	--use of community resources?	5	4	3	2	1
16.	--laboratory and field-work integral to and integrated with the curriculum?	5	4	3	2	1
17.	--opportunities for students to have personal interaction with people practicing science?	5	4	3	2	1
18.	--concern for career awareness?	5	4	3	2	1
19.	--opportunities for students to work together to investigate a scientific/ technological problem?	5	4	3	2	1
20.	--opportunities for students to work with a mentor to investigate a scientific/ technological problem?	5	4	3	2	1
21.	--use of various questioning strategies integrated throughout the curriculum?	5	4	3	2	1
22.	--active student involvement required by curriculum?	5	4	3	2	1
23.	--scientific process demonstrated as approximation versus absolute rigidity?	5	4	3	2	1
24.	--students are taught to build and test hypotheses?	5	4	3	2	1
25.	--allowance for questioning of assumptions and diverse opinions?	5	4	3	2	1
26.	--examples of unsuccessful science so that science-as-a-process is demonstrated?	5	4	3	2	1

Tailoring for Special Populations Evaluation Form
(Phase III Review)

Name of Reviewer: _____

Title: _____

Title of Curriculum to be Reviewed: _____

_____ Appropriate Grade Level(s): _____

Although curriculum may be found exemplary from a technical and even subject area perspective, it is important to consider the extent to which curriculum can be tailored to the needs of more targeted groups of learners with special needs. Thus the Level III review process looks more closely at the features of exemplary curriculum for special populations.

Directions: Carefully re-read through all curriculum materials and then, rate the curriculum by each of the following criteria on a scale of 5 = To an Exemplary Extent; 4 = To a Good Extent; 3 = Adequate; 2 = To a Limited Extent; and 1 = Not at All.

	Differentiation for High Ability Learners	**5**	**4**	**3**	**2**	**1**
1.	--provisions for acceleration and compression of content?	5	4	3	2	1
2.	--use of higher order thinking skills (e.g., analysis, synthesis, evaluation)?	5	4	3	2	1
3.	--integration of content by key ideas, issues, and themes?	5	4	3	2	1
4.	--connection of scientific ideas to other disciplines?	5	4	3	2	1
5.	--opportunities for both inductive and deductive reasoning?	5	4	3	2	1
6.	--use of multiple teaching resources?	5	4	3	2	1
7.	--use of diagnostic-prescriptive teaching?	5	4	3	2	1
8.	--attention to instructional pacing?	5	4	3	2	1
9.	--advanced reading level?	5	4	3	2	1
10.	--opportunities for students to develop advanced products?	5	4	3	2	1
11.	--opportunities for independent learning based on student capacity and interest?	5	4	3	2	1
12.	--use of inquiry-based instructional techniques?	5	4	3	2	1
A.	**Curriculum Responsiveness to the Intellectually Gifted**	**5**	**4**	**3**	**2**	**1**
	--sufficiently advanced in content?					
	--sufficiently challenging?					
	--complex applications of concepts?					
	--product demands appropriately designed?					
B.	**Curriculum Responsiveness to the Science Prone**	**5**	**4**	**3**	**2**	**1**
	--opportunities for extended and independent learning?					
	--opportunities for open-ended exploration?					
	--opportunities for in-depth work on selected topics?					

C. **Curriculum Responsiveness to Girls** | 5 | 4 | 3 | 2 | 1 |

--presence of information about contribution of women to science?

--opportunities to read about women in science?

--information provided about career opportunities for women?

--avoidance of bias and sex stereotyping in resource materials?

--use of varied teaching strategies, including hands-on, discussion, and cooperative learning?

--use of conceptual organizers for teaching new material?

D. **Curriculum Responsiveness to Minority Concerns** | 5 | 4 | 3 | 2 | 1 |

--incorporation of effective social experiences?

--promotion of tolerance of self and others?

--global perspective with attention to non-Western cultures?

--emphasis on cultural similarities and differences?

--emphasis on analogical reasoning and associative thinking?

--presence of information about contribution of minorities to science?

--opportunities to read about minorities in science?

--information provided about career opportunities for minorities?

--avoidance of bias and ethnic stereotyping in resource materials?

E. **Curriculum Responsiveness to Disabled Students** | 5 | 4 | 3 | 2 | 1 |

--options for individualized programming?

--data-based instructional decision-making?

--opportunities for variety of response modes?

--on-going collaborative planning for present and future environments?

--provision of tools for compensation?

--preparation for career/vocational and independent living skills?

--use of varied formats for guided and independent practice?

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GEMS
Great Explorations in Math and Science
Lawrence Hall of Science
University of California
Berkeley, CA 94720
Grades K-10

OVERVIEW

Description

GEMS is a program of guided discovery that enables instruction of both science content and process skills through hands-on activities. There are currently more than 30 units in the GEMS program, each focused on a single topic and described in its own teacher's guide. A teacher's handbook gives an overview of all the GEMS materials and makes recommendations for using the units, either as supplements to existing curriculum or as a stand-alone curriculum organized by suggested themes. Several of the units, such as Quadice and Height-O-Meters, focus on math concepts. The rest are science units with a strong mathematical component. The only materials provided for students are data sheets (masters are included in teacher's guides). There are no textbooks. Each guide presents a comprehensive set of directions for hands-on activities with supplemental background information and suggestions for extensions. The activities require readily available, inexpensive materials. No special training in math or science is required for teachers although training sessions are available if desired. Each guide indicates a range of recommended grade levels. Time frames are flexible, ranging from 2 to 15 class sessions per unit.

GEMS is a dynamic set of materials. Its modular design facilitates the addition of new units. One of two new units due to be published in Spring of 1992 is called "The Bubble Festival." Designed for grades K-6 this unit is structured around the use of a learning station. An extension handbook for literature is to be published in Fall of 1991. Teachers are encouraged to send anecdotes and ideas for later revision of existing units. Lawrence Hall of Science (LHS) publishes a newsletter called "GEMS Network News" that includes letters from users of the materials, reponses to those letters, and ideas from LHS.

Major Program Goals

The major objectives of the GEMS program are:

- To create independent learners and critical thinkers.
- To increase students' understanding of pivotal science and mathematics concepts.
- To promote mastery of key science and mathematics skills.
- To build positive attitudes towards science and mathematics.

Research Evidence of Effectiveness

An intense formative evaluation procedure is followed in the development of all GEMS units. Potential activities are tested in classrooms and either modified or eliminated as feedback indicates. Eight to ten local classroom teachers (urban and rural, experienced and novice, young and old) field test the guides. The teachers fill out detailed evaluation forms and each session is observed by a GEMS team member. This data is used to revise the guides, which are then sent to 100 teachers at five national trial sites. More evaluation forms are collected and revisions are made again. A limited number of units are printed, used, and polished before nationwide distribution of the final product.

Additional research has been conducted on three of the units.

- "Children's Cosmographies: Understanding the Earth's Shape and Gravity" (1) describes the seminal research that laid the foundations for the Earth, Moon, and Stars guide. The study found that children's notions about the earth's shape and gravity are often incorrect, result from observed phenomena and cultural transmission of information, and are affected by verbal and spatial abilities. Results also indicate that mature concepts are acquired gradually, usually culminating by the seventh or eighth grade. The findings imply the need for effective education in these concepts.

- "The Experiences of Visitors in a Physics Discovery Room" (2) evaluates the effectiveness of the exhibits described in The Wizard's Lab. The authors conclude that visitors in a science discovery lab do engage in the kind of learning activities that lead to both enjoyment and understanding. However, the study was not designed to determine whether there is an increase in understanding.

- "Learning to Control Variables With Model Rockets" (3) tested the educational effects of Experimenting With Rockets. Results indicate that 9-15 year-olds who were exposed to the rocketry program significantly improved their ability to control variables.

ANALYSIS

General Curricular Features

Curriculum design.

The GEMS approach to teaching science is "doing before explaining." The units are intended to illustrate essential scientific concepts and methods while engaging the student in critical thinking and hands-on activities. Activities within each unit build on one another so that they are not simply a collection of experiments on a single topic. A supplemental publication, "To Build a House," outlines ten major themes that run throughout GEMS materials. These themes are: systems and interactions, stability, diversity and unity, models and simulations, matter, patterns of change, energy, evolution, structure, and scale. A chart is provided to help teachers identify the units where each theme is featured. Themes can be highlighted for an individual unit or an entire curriculum can be organized around selected themes. A second chart lists the nine categories that illustrate the nature of science and also the units which feature each category. These categories are: scientific community, science and technology, changing nature of facts and theories, creativity and constraints, theory-based and testable, cooperative efforts, objectivity and ethics, real-life applications, and interdisciplinary. Sample year-long science programs for grades 3, 6, and 8 are included.

Classroom Implementation.

The primary roles of the teacher in the GEMS program are a facilitator of science activities and a discussion leader. The teacher sets up materials for the planned activities. Data sheet masters are provided in the teacher's guide but very little other material is provided for the students. The data sheets are not step-by-step activity sheets that lead students through every aspect of the lesson in "spoon feeding" fashion but provide a convenient format for recording data. Directions are usually read to students. Often students are instructed to design or re-design an experiment. For example, in Hot Water and Warm Homes From Sunlight, the students are asked

to design a controlled experiment to determine whether a covered pan or an uncovered pan produces warmer water when placed in sunlight.

Ample opportunities are provided for problem finding and solving. Teachers are encouraged to create questions in the open-ended style of the examples given in the unit guides. Students usually work in small teams. The teacher handbook emphasizes experimenting and drawing conclusions as opposed to getting the "right answers."

GEMS units can be implemented as whole class activities with students working in small groups. Materials and directions could also be set up at a learning station in the classroom for use as enrichment or extension for an individual or small group, provided the students are able to function without constant guidance from the techer.

GEMS does not provide specific pre- and post-assessment procedures for most units. Earth, Moon, and Stars has a questionnaire that could be used for both purposes. Teachers are given suggestions for alternative assessment procedures such as collecting observational data on student behaviors, having students write what they know before and after each activity, posing a new problem where the students are expected to apply what they have learned, and doing a demonstration where errors are made and students make suggestions for improvement.

The teacher's guide is very easy to follow. Summary outlines are included at the end of each guide and can be used as checklists during class. A section in each guide, called "Behind the Scenes," provides background information for teachers. Some units have a "Resources" section that is mainly for teacher use but could be a source of extension material for a highly able learner. Each unit contains a section called "Going Further" that is rich in open-ended extension ideas for whole class activities or individual projects. Some examples are:

- In Bubbleology students are asked to develop their own ideal bubble solution.
- Also in Bubbleology students are instructed to determine the volume of their lungs by blowing bubble domes.
- In Acid Rain students plan and carry out their own investigation of the effects of acid on various materials such as brick, nylon, styrofoam, concrete, marble, wood, etc.

Technology.

The use of technology is not featured in this program.

Exemplary Science Features

Science content.

The material presented in the GEMS units displays many characteristics of exemplary science. The concepts are significant and are covered in sufficient depth to do them justice. The information is accurate and presented well with a nice balance of theory and practical applications. Mathematics is effectively integrated into the science activities. Many other interdisciplinary connections are also provided. Reading about the discovery of vitamin C and mixing paint colors are examples of connections to history and art. Some teachers have students keep a laboratory journal. Assessments can be done as writing exercises or as authentic science activities.

Many environmental issues are presented in the GEMS units. They include acid rain, global warming, toxic waste, and energy conservation. These can be used as the basis for discussion of ethical aspects of our treatment of the planet and its inhabitants.

Science process.

Scientific process skills are skillfully demonstrated in the GEMS units. The activities avoid verification exercises or demonstrations by the teacher. Excellent opportunities are included for hands-on scientific investigation. Students work together in lab work where they are expected to form and test hypotheses. The emphasis is on critical thinking rather than merely generating "right answers." This is reflected in the questioning style that is modeled in the guides. There is room for things to go wrong and for diversity of opinions. The discussion sessions after experiments are valuable opportunities for students to learn how to deal with conflicting results. The scientific convention in Oobleck: What Do Scientists Do? provides a marvelous view of the kind of discussion and analysis of scientific findings that is actually found in the scientific community. It is also an exercise in communication skills for students. The GEMS program communicates a realistic sense of what scientists do--questioning, investigating, and making sense of the world in a cooperative way.

Links to real scientists, mentors, and community resources are not featured in this program. However, the teacher or a community person could act as a mentor for students who might pursue extension activities as individual projects. Career awareness is not stressed, but the Oobleck unit does a good job in demonstrating how scientists function and concludes with specifics about scientists working in space exploration.

Tailoring for Special Populations

Differentiation for high ability learners.

GEMS contains many key components of a good science program for high ability learners. Among them are:

1) Inquiry-based activities that include true experimental work.
2) Independent lab work.
3) Scientific reporting.
4) Problem finding, solving, and reevaluation.
5) Concepts that are significant and challenging.
6) Higher level thinking skills that are encouraged by the structure of the activities and the style of questioning.
7) Opportunities to develop advanced products.
8) Opportunities for extension activities that can be adjusted for student ability and interest.
9) Identification of themes throughout the GEMS units. These can be emphasized with high ability students in a meaningful way since high ability students are readily able to handle abstract approaches of organizing concepts. The use of the booklet, "To Build a House," is strongly recommended as a teacher resource for this purpose.
10) Emphasis on creative thinking.

If these materials are used as a supplement to another set of curriculum materials then it is not necessary for them to include every aspect of a model curriculum for high ability students. However, as a stand-alone curriculum several areas should be supplemented for these learners. For example, there is not an obvious provision for testing out of certain portions of the curriculum. The acceleration of content needs to be managed by the teacher. If she has some

method to diagnose the needs of her students, then selection of units, pacing of activities, assignment of independent work, and emphasis of themes can be done meaningfully for high ability students. Moral and ethical dilemmas associated with relevant issues should be considered and debated. Also, scientists, community resources, and mentors are not incor, orated into the units, but these features can be provided through other resources.

GEMS materials could be used as enrichment supplements for high ability students in a heterogeneous classroom where the rest of the class is working from a basal text. Some of the activities could be adapted in a learning center format. In a classroom where a GEMS unit is being used by the whole class, there are a number of suggested extension activities that would serve to challenge high ability students. In a self-contained class of high ability students the early activities in each unit could be done quickly leaving time for the later experiments and more open-ended activities that would be most appropriate for these learners.

Other special populations

The GEMS materials contain no special features that are particularly responsive to female, minority, and disabled students.

CONCLUSION

GEMS is a program that would benefit all students with its emphasis on scientific process and its hands-on approach. However, it is a program that holds special promise for high ability and gifted learners because of its orientation toward higher level thinking, creative thinking, and opportunities for extended investigations.

REFERENCES

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Curriculum Evaluation Form

GEMS

	Phase I Review 3 2 1	
Curriculum Design Features		Average Rating
Reviewer #1	2.73	2.71
Reviewer #3	2.69	(Scale 1-3)
Classroom Design Features	3 2 1	Average Rating
Reviewer #1	2.63	2.68
Reviewer #3	2.72	(Scale 1-3)
Technology Features	3 2 1	Average Rating
Reviewer #1	NA	NA
Reviewer #3	NA	

	Phase II Review 5 4 3 2 1	
Science Content		Average Rating
Reviewer #1	4.16	4.16
Reviewer #2	4.16	(Scale 1-5)
Science Process	5 4 3 2 1	Average Rating
Reviewer #1	3.78	3.82
Reviewer #2	3.86	(Scale 1-5)

	Phase III Review 5 4 3 2 1	
High Ability Learners		Average Rating
Reviewer #1	3.75	3.79
Reviewer #3	3.83	(Scale 1-5)

Consumer's Guide Rating Form

	Scale 1-3			Scale 1-5			
Title of Materials	Curriculum Design	Classroom Design	Technology	Exemplary Science Content	Exemplary Science Process	High Ability Learners	Notes
Great Explorations in Math and Science (GEMS)	2.71 +	2.68 +	NA	4.16 +	3.82 +	3.79 +	A, B

Rating Scale:	Recommended = +	Adequate = 0	Not Recommended = √
(1-3 scale)	2.34 - 3.00	1.67 - 2.33	below 1.67
(1-5 scale)	3.70 - 5.00	2.30 - 3.69	below 2.30

Note: Appropriate for (A) Intellectually Gifted; (B) Science Prone; (C) Girls; (D) Minorities; (E) Disabled Students